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DECAY IN CITRUS FRUITS DURING TRANSPORTATION.

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INTRODUCTORY.

In most fruit it takes fifty-one weeks to produce the crop and in one week it is marketed. In this one week fifty-one times more care should be taken than in any one of the previous weeks. However, here is where many producers fail——they take less care during the process of marketing their fruit than they do in growing it!.

CLASSIFICATION OF CITRUS FRUIT DISEASES.

After working on the markets for some time it became apparent that the old classification of fungi as parasites and saprophytes did not meet the demands of the business men. We therefore attempted to classify the diseases in three categories:

1. Diseases which cause damage in the field and in the field only.
2. Diseases which cause damage in the field, and which are able to develop or spread during the process of marketing.
3. Diseases which occur during the process of marketing and may be induced by the methods of marketing.

CITRUS FRUIT DISEASES DEFINED.

When we speak of disease we mean anything on the fruit which is abnormal and which to the merchant is a defect and adversely affects the selling price of the product.

In the first category are included such defects and diseases as thrip injury, scale, anthracnose, tear-staining, scab, melanose, thorn injury, fumigation injury and tree scars. Fruits with these characteristics are usually packed in the lower grades, but may sometimes be packed in the better grades. When this kind of fruit is placed in the better grades, either by mistake or on purpose, then the Food Products Service may be called upon for an inspection. These defects are not the ones which have given the most trouble, for the worst have been discarded in the packing house.

In the second class belong the treacherous citrus diseases, those which cause decay. They develop during the process of marketing and are of gravest concern to the grower, shipper and buyer. The following are the most common of these diseases: Stem-end rot, brown rot, gray-mold rot, alternaria rot and cottony rot. It is plainly apparent that these are troubles of the growers. All California shippers know the great losses they sustained a few years ago from brown rot. Not only did apparently sound lemons decay on the way to market, but lemons decayed on the trees and the trees themselves were affected with gummosis. Very little need be said of the other troubles with the exception of stem-end rot.

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THE FUNGUS PHOMOPSIS CITRI.

In 1909 Prof. H. S. Fawcett found that the fungus *Phomopsis citri* was causing a great loss to the Florida citrus grower. It was noticed that a heavy dropping of fruit occurred and that all the dropped fruit began to decay at the stem end. In fruit affected with this disease, softening of peel and underlying pulp begins almost invariably at the stem end and extends rapidly until the whole fruit is involved. In the early stages there is little or no discoloration, but soon a light brown discoloration is apparent. The rot progresses rapidly down the central axis, and usually reaches the blossom end by this route sooner than through the surface peel. There is sometimes a tendency to extend in the peel most rapidly along the lines marking the divisions between the fruit segments. At ordinary temperatures the rot may extend an inch a day, requiring four or five days to completely rot the fruit. The fruit does not shrivel or lose its shape unless subjected to pressure. Fruit which has been allowed to remain under the tree for some time becomes covered with a grayish colored fungus.

Isolations from freshly-fallen fruit showed that the fungus was the same as that on the outside of the old decayed fruit. Sound fruit inoculated with pure cultures of this fungus decayed in like manner as those in the field. Thus it was established that *Phomopsis citri* was a cause of stem-end rot of citrus fruits.

At this same time considerable decay was occurring during transit which could not be explained. Decayed and affected specimens were sent to the Florida station from the northern markets and the same fungus again was isolated. Those fruits had been packed in apparently sound condition, but on their arrival at the market were found decayed. From certain groves losses as high as 75 per cent were sustained. It was found that some fruit began to decay five weeks after shipment.

SHIPPING EXPERIMENTS.

Some shipping experiments were conducted in cooperation with the United States Department of Agriculture (Bureau of Markets). It was found in a certain shipment on arrival in Washington there was a 1.5 per cent loss.

One week after arrival, 8.5 per cent decay.

Two weeks after arrival, 22.3 per cent decay.

Three weeks after arrival, 36.7 per cent decay.

Evidence seems to point to the fact that the fruit was infected at the time of shipping.

Dipping of field boxes in disinfecting solutions seemed to have no effect on the percentage of decay, for the reason stated above that the fruit was already infected when picked.

STEM-END ROT DEVELOPS IN TRANSIT.

One of the great troubles with the selling of citrus products is that on account of stem-end rot the buyer does not know what he is getting. This fungus develops on the way to market to such an extent that the loss runs as high as 50 per cent. Therefore the buyer must take this fact into consideration and buy on a margin so that he is protected. The grower and not the buyer is the loser. Therefore, it should be emphasized that the work on stem-end rot needs vigorous prosecution.

This disease is getting worse each year, and until a control is found the losses will be great.

There were only one hundred inspections of citrus fruits asked for up to January 1, 1919, last season. This does not mean that only one hundred cars arriving on the market showed stem-end rot, but it does mean that there was a dispute over adjustment of the losses occurring in one hundred cars of fruit. Therefore the United States department inspector was called in to give a third opinion. About the middle of October stem-end rot showed up worse; 42 per cent of the fruit examined showed the disease. At the middle of November there was a 28 per cent loss. The amount kept on decreasing until the first of January, when there was no stem-end rot showing up in cars for which inspection was asked. An average of 24 per cent of stem-end rot was found in cars inspected up to January 1. This disease kept appearing on the market throughout the year, but there was more decay before January 1 than after that date.

Fruit may be picked and packed that shows no signs of decay, yet, when it arrives on the market, a goodly per cent has decayed. This is the reason so many growers do not believe the receivers when the latter state that a certain per cent is affected with stem-end rot.

HOW TO SHIP.

All fruit should be packed as quickly as possible and pre-cooled or shipped out under refrigeration so as to check the growth of the fungus. The stem-end rot fungus grows best at about 80°. If the fruit is already infected when it enters the cars refrigeration will not stop the growth of the fungus, but will only check or slow down its growth.

LEMON DECAY DUE TO PHOMOPSIS CITRI.

During the 1919-20 season, while investigating the decay of citrus fruits on the market, stem-end rot was found on California lemons. Cultures made from decaying lemons showed the fungus to be *Phomopsis citri* (Fawcett). This is the first time that this fungus has been found in California citrus fruits. Immediately the inspectors were asked to keep a lookout for this rot on California lemons. Specimens were sent in from Chicago, New York, Philadelphia and Washington, D. C. These lemons came from the Santa Barbara district. We immediately informed the California Citrus Station of our find and asked them to send some one to that region to investigate the situation. Prof. Fawcett went to the Santa Barbara district and found the disease in the field. Lemons decay in the same manner as described for stem-end rot of oranges from Florida. He states that he found the fruiting bodies of what appeared to be the same fungus on the dead and dying twigs. It behooves each grower, therefore, to keep a strict watch for this disease and take measures to stamp it out of his grove as soon as found.

METHODS ADVISED FOR FLORIDA.

1. Prune out all dead and diseased twigs and limbs.
2. Destroy old fruit.
3. Cull and carefully handle all fruit.
4. Cool the fruit as quickly as possible, and keep it cool.

PREPARING CALIFORNIA LEMONS FOR MARKET.

In California the great loss in some packing houses may be due to the methods used in preparing lemons for the market. This disease probably has been taken for brown rot or gray mold rot.

Since, as Fawcett says in his Florida Bulletin, "the evidence at hand indicates that in actual practice most of the germs of decay are in the fruit at time of picking," we can only expect increasing losses during the transportation if the fungus should spread to other groves in California not now affected. It also is the grower's duty to see that his groves are free from this disease.

BLUE MOLD OF CITRUS.

The third class of diseases is that which arises during the process of transportation and marketing, and are induced by these methods. Blue mold of citrus has caused more loss in the past to the citrus industry than any other one disease. This fungus develops from a small spore, but is unable to penetrate the sound skin. The first stage of the decay is a softening at the point where the fungus has entered the fruit. This is always found to be at some injury or puncture. It never appears on a perfectly sound and uninjured orange.

In Bulletin 123 of the United States Department of Agriculture, Mr. G. Harold Powell states, on page 20, speaking of the blue mold decay:

"The causes of the decay were not understood, but a multitude of theories were advanced by growers and shippers to explain it. Some attributed the decay to the influence of the type of soil and to other conditions under which the fruit was grown; to a possible degeneracy in the fruit as the trees grew older, and to climatic conditions, such as frequent fogs and rains. The decay was thought by many to be especially related to a supposed inherent weakness of the fruit during the blooming period of the trees, which occurs during the picking season. Others believed it to be due to methods practiced in the packing houses, while nearly all were more or less agreed that a large part of the loss was chargeable to inadequate or improperly handled transportation facilities. The decay entailed a heavy loss on the shipper, it was detrimental to the reputation of the industry, and it led to difficulties of various kinds between all parties concerned in the handling and transportation of citrus fruits."

On page 22, speaking of the kind of wounds on fruit which might be possible places for infection of blue mold, Mr. Powell says: "The effect of different kinds of cuts and abrasions on the fruit appeared important. A slight puncture or the removal of bits of the epidermis by scratches or by shaving it with the picking shears would frequently dry before spores could germinate and become established. A deeper wound, especially in the body of the fruit, where the skin is thin, would usually fill with juice and provide an ideal condition for rapid decay. It was noticed that decay did not develop in these slight wounds, while it was almost sure to develop in the deeper wounds unless the fruits was held in an unusually dry or cold atmosphere."

On the same page he says: "Without puncturing the skin, the mold spores were placed on the surface of oranges which had been delivered at the packing house in the usual commercial way and were apparently

sound. This fruit was held for one or two weeks in the house, where conditions were favorable for the germination of the spores and for the development of decay, and then examined. It was rare to find that decay had developed at the point where the blue mold had been placed on the fruit. Decay, however, sometimes developed where no mechanical injuries were visible. In these cases the mold probably entered the skin through injuries caused by the punctures of insects, by the dropping of the fruit or through other injuries not discernible."

In Bulletin No. 108 from the Florida Agricultural Station, Prof. Fawcett says that blue mold can largely be prevented by extreme care in picking, handling and packing, since it follows injuries to the fruit.

In Bulletin No. 262 of the University of California, on page 187, Prof. Fawcett says, speaking of the blue mold: "These fungi are apparently unable to enter except through imperfections or injuries of the skin of the fruit. It has been found by many experiments that a large part of this decay may be avoided by the careful picking, packing and shipping of fruits."

In the quarterly bulletin of the State Board of Florida, Vol. 2, No. 4, on page 163, the author of the article states: "If the fruit could be handled from the tree to the market without clipper cuts, injuries or bruises there would be no loss due to blue mold, for there would be no way in which the blue mold fungus could gain access in the sound fruit." He suggested in the article the remedies for blue mold, such as cleanliness in packing houses, scrubbing of boxes once a week with soap and water and more care in handling the fruit between the grove and the packing house.

In a pamphlet issued by the California Fruit Growers' Exchange, March 1, 1917, written by Pratt, on page 14, is found the statement, "Blue mold can only attack the fruit through injuries of some sort; it can not rot a perfectly sound orange or lemon."

The power of the fungus to grow in healthy oranges in commercial cold storage has been tested by inoculating fresh fruits with the mold spores in a puncture through the epidermis and placing them at once in a temperature of 32° F. or less. Decay had not developed in two months, when the test ended.

In Bulletin No. 63 of the United States Department of Agriculture, A. V. Stubenrauch and H. J. Ramsey, pomologists, with a corps of workers, have recorded experiments which they conducted in the handling and shipping of Florida oranges. On pages 38 and 39 they show diagrams for the handling of fruit. On page 39 there is a diagram which shows that one house lost 59.5 per cent of a certain shipment by its careless handling. When careful handling methods were used they lost only .7 of 1 per cent of the fruit. In another house a loss of 5.7 per cent of fruit was sustained, but by careful handling this was reduced to 2.7 per cent.

On page 48 they make the following statement: "More than 90 experimental shipments of oranges were made from Florida in 1910-11, and 65 were sent out in 1911-12, including fruit from every section of the state and from good, poor and average houses. The carefully picked, graded and packed fruit showed 35.6 per cent and the

commercially handled fruit had 65.9 per cent. After one week these had increased to 4 per cent, 46 per cent and 71.6 per cent, respectively; after two weeks they were 11.5 per cent, 54 per cent and 72.2 per cent; and after three weeks, 11.5 per cent, 57.1 per cent and 72.2 per cent.

"The carefully handled fruit arrived in Washington during both seasons with less than 1 per cent of decay, or an average for the two years of 0.6 per cent for all the experimental shipments. The fruit handled under commercial conditions throughout had developed more than twice as much decay by the first inspection as occurred in the carefully handled fruit at the end of three weeks."

While in Florida last October the writer delivered a lecture at the Citrus Seminary of the University of Florida and heard Mr. Stewart, one of the citrus exchange men, make the statement that Florida had improved in its handling methods by the work of Mr. Ramsey, but since that time they had backslid and were beginning to handle their fruit more carelessly than they had during Mr. Ramsey's active work in Florida. I am well aware of the fact that during the fall of 1918 and during the shipping season of 1919 there has been a great deal of decay due to blue mold and this, I believe, is due to improper handling in the field.

SUMMARY.

The writer has tried to show that the two great diseases of citrus fruits, arriving on the market, are stem-end rot and blue mold decay. Stem-end rot is a field disease. The fruit is infected in the field, and it is the duty of the grower to stamp it out of his groves. If fruit arrives on the market decayed and all precautions were taken during transportation the grower is the loser. Railroad companies and commission merchants are asking for the truth so that claims can be adjusted. These concerns are awake and show signs of active campaigns in methods of disease control

In the case of blue mold it has shown that it is due to careless handling. If cars have been properly handled during transportation and decay begins, the railroad companies are not responsible and they are fighting claims for loss in such cases.

If the product arrives on the market in an unsightly, decaying mass, it sells as such. The good fruit is sold at a lower price on account of the decayed fruit in the same boxes.

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